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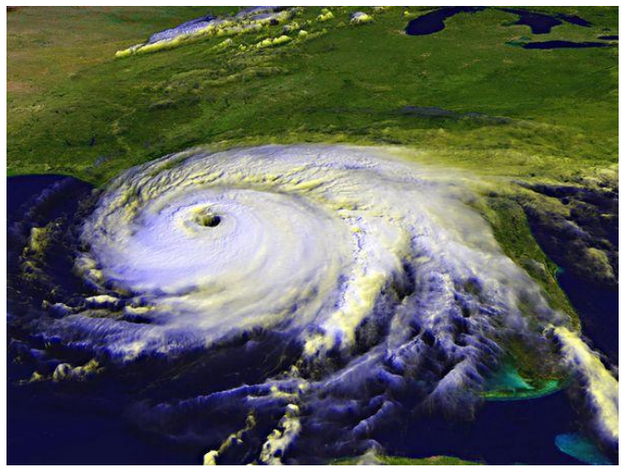

Energy Storage Demonstration and Analysis: ESS in Grid-Level Setting

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ES Grid-Level Projects

Mission: Advance energy storage systems and evaluate cost effectiveness, performance, safety and reliability.

EXAMPLES

- Feasibility Study
  - Cordova, Alaska
- Factory Acceptance Testing, Commissioning and Analysis
  - Puget Sound Energy
- Application and Optimization
  - Base Camp Integration Laboratory

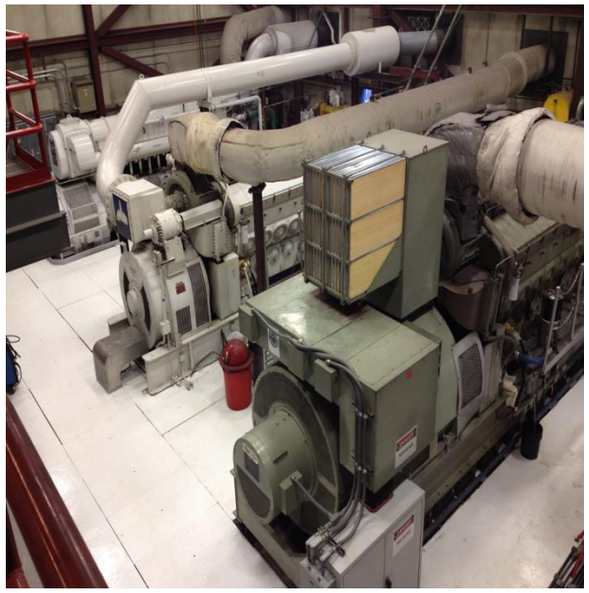
  Limited Discussion of system.

Cordova Hydroelectric/Energy Storage Feasibility Study

- Players
  - Cordova Electric Cooperative (CEC)
  - US DOE/OE and Sandia National Labs (SNL)
  - Alaska Center for Energy and Power (ACEP)
- Issue
  - Expansion of fishing industry has exceeded the supply capability of the 8.5MW hydroelectric plants which supplemental power demand is met with diesel generation.
  - Supplemental power by diesel generation is only needed for minutes
  - Hydro units are run with a 500kW reserve which energy storage can free up and defer diesel generation
- ACEP with SNL and has developed an energy balance model to determine feasibility of an energy storage system installed on the Cordova system

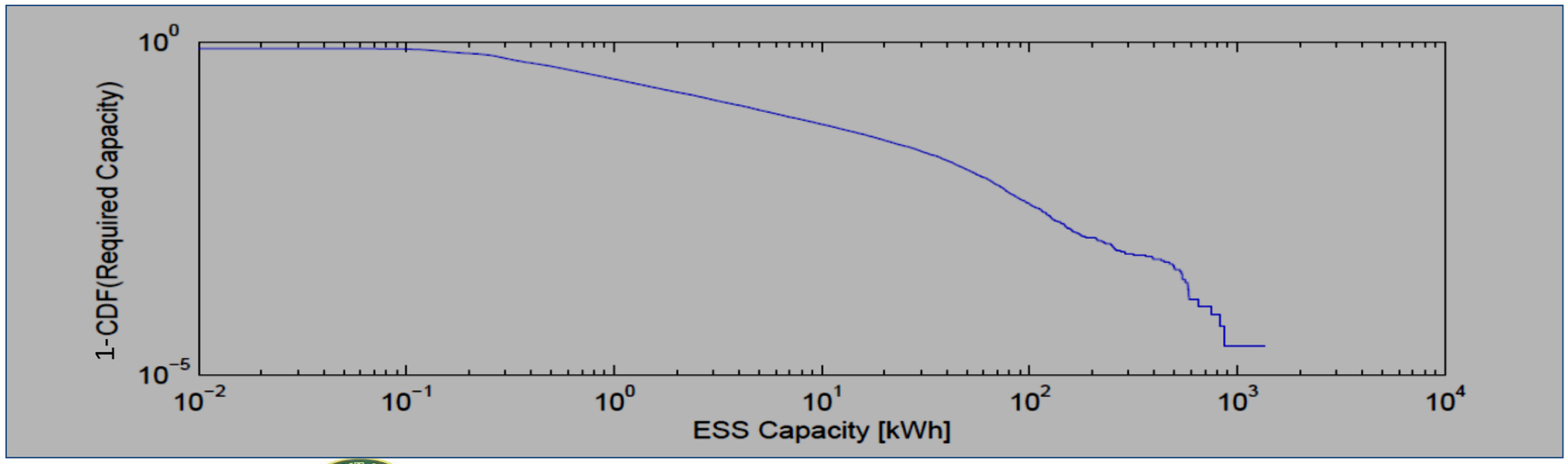
Cordova Electrical System Overview

- Member-owned COOP serving 2,000 customers with summer load peak of 8.4 MW
- Generation Assets
  - Pump Creek: 2 hydro units, 3 MW each
  - Humpback Creek: 2 hydro units, 1.25 MW each
  - Orca Power Plant: 5 diesel units, Total of 9.8 MW
- Distribution system is underground
- SCADA system records over 200 channels of systems data at 1 second intervals with over 10 years worth of data

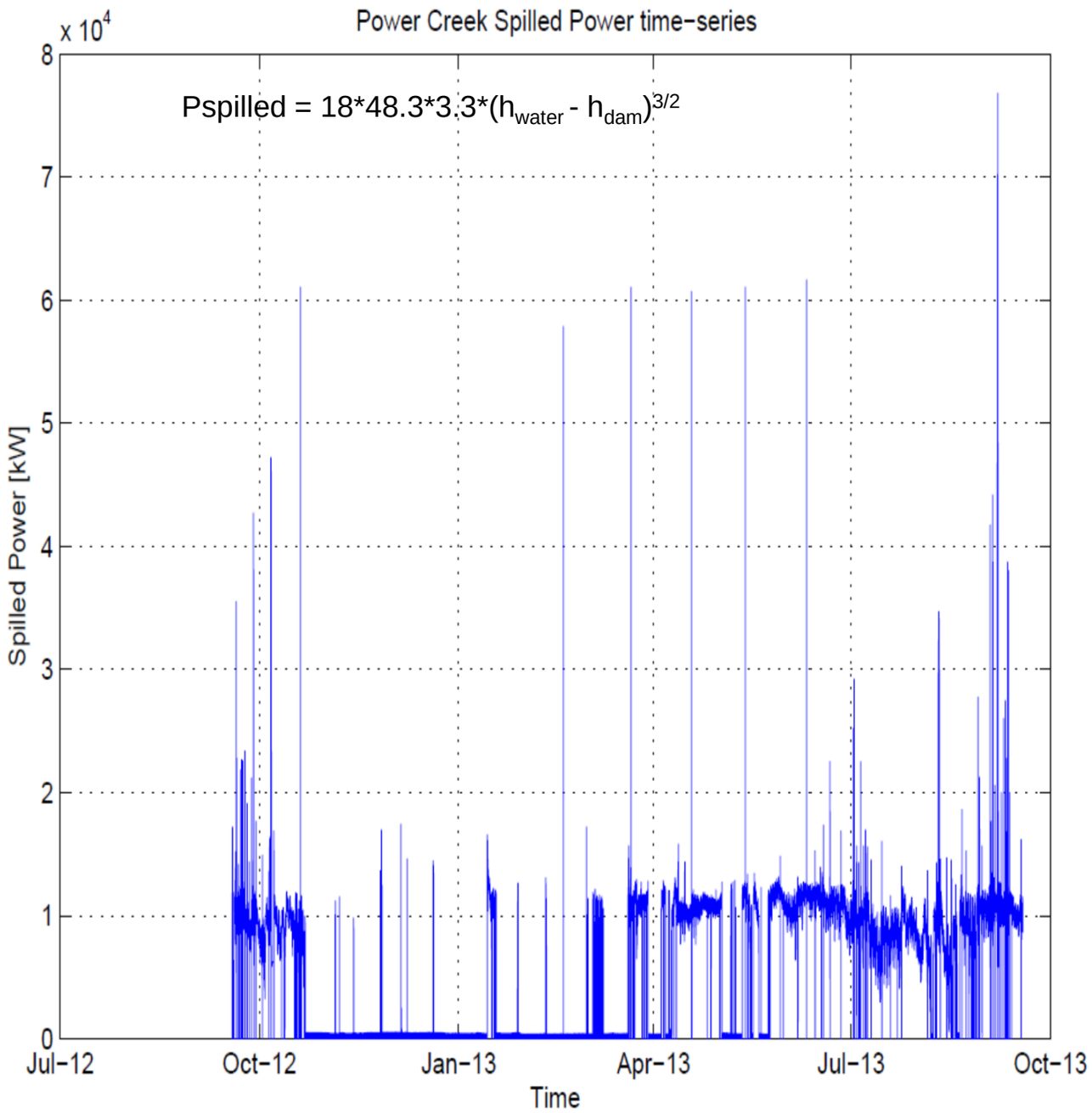


Results of Energy Balance Model

- Total hours per year within 500kW of spinning reserve while running on hydro power was 215.9167 hours
- Total displaceable diesel hours is 185.4589 hours
- Assuming electricity cost of $0.45/kWh, economic value of energy storage systems is ~$54,640/year
- Power class energy storage system will not have significant economic benefit for Cordova used for diesel displacement



Summary/Conclusions



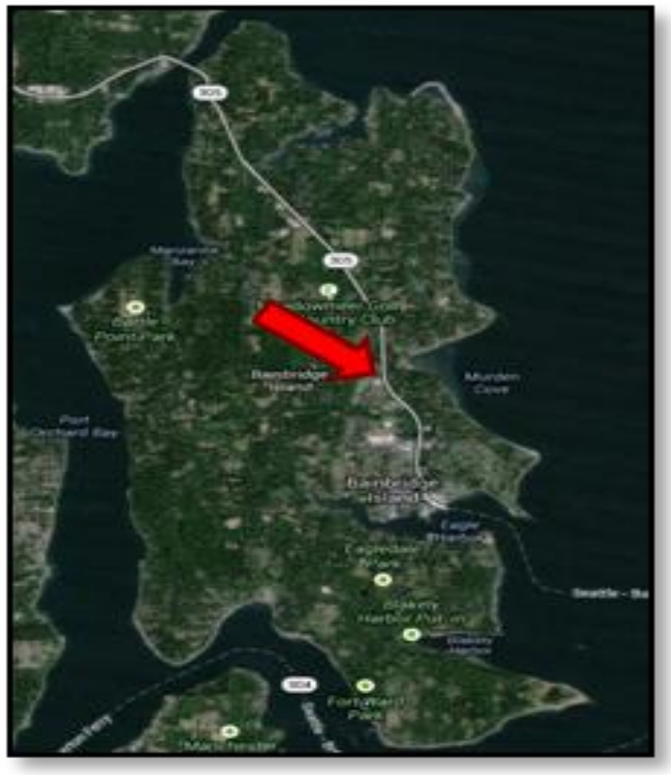
- Recovering water spilled during times when load demand is below the hydropower capacity has a beneficial impact
- Initial economic benefit of $750,000/year off-setting thermal loads
- (~14x better return)

Future Tasks

- Establish New Energy Balance Model for Capturing Water Spilled
  - Distributed thermal storage units
  - Electrochemical energy storage
- Develop Dynamic Model for Energy Storage Based On Energy Balance Model
  - Size Specifications
  - Control of single or multiple devices
- Use developed process and model for replication which will be coordinated through a partnership with DOE Indian Affairs

Puget Sound Energy Flow Battery Energy Storage System

- Players
  - Puget Sound Energy (PSE)
  - Bonneville Power Administration (BPA)
  - Primus Power
  - DOE/OE and Sandia National Labs (SNL)
  - Pacific Northwest National Laboratory (PNNL)
- Project Objectives
  - Install and analyze an innovative 0.5 MW / 1.0 MWh Zinc Bromide flow battery system from Primus Power
  - Develop best practices for commissioning an energy storage system
  - Assess (and demonstrate) the benefits of energy storage on the distribution grid



Current Status of Project and Future Effort

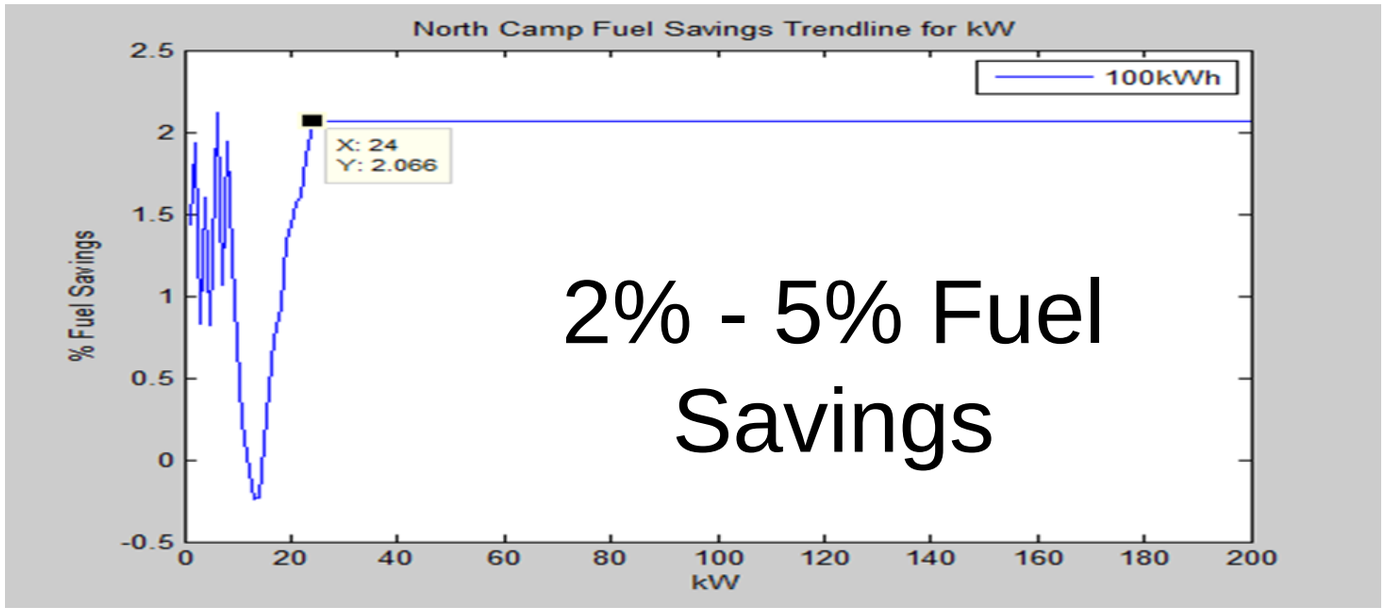
- Currently
  - Developing Factory Acceptance Test (FAT) document PSE to serve as the lead entity
  - Incorporating Sandia's lesson learned document for commissioning
- Future
  - Develop commissioning tests, including
    - Field or Operation Acceptance Test
    - Functional Acceptance Test
  - Complete Performance Evaluation
    - Team will monitor installed energy storage system for a period of time to evaluate performance for peak shaving, renewable integration and uninterruptible power supply based on PNNL performance metrics document
    - Change/ modifyapplication of energy storage system based on performance evaluation

Energy Storage Incorporated into a Forward Operating Base (FOB)

- Players
  - Army Program Manager Force Sustainment Systems (PM FSS)
  - GS Battery
  - Raytheon/Ktech
  - MilSpray
  - Princeton Power Systems
  - US DOE/OE and Sandia National Labs (SNL)
- Project Objectives
  - Analyze energy storage's capability to increase the reliability of the electrical power microgrid at a FOB while decreasing the fossil fuel consumption of the system

FY14 Accomplishments at Energy Storage Test Pad (ESTP)

- RFI issued based on Army Regulations and Sandia Applications
  - Milspray, Lead Acid
  - Princeton Power, Li-Ion
  - Raytheon/Ktech, Zinc Bromide
  - GS Battery, Lead Acid
- Completed Operation Analysis at Sandia's ESTP
  - Published SAND reports of testing results
- Developed predictive fuel savings model



Accomplishments at BCIL

- Completed first round of functional analysis at Base Camp Integration Laboratory (BCIL)
  - Princeton Power and GS Battery energy storage system completed
  - Princeton Power sent ESS to MIT Lincoln Labs (MIT/LL) for further evaluation

Current Project Status and Future Efforts

GS Battery Rendering of RESCU unit with PV

- Currently
  - GS Battery HES RESCU unit is being engineered to be hardened to increase capability for grid forming
- Future
  - Analyze GS Battery HES RESCU unit at BCIL with new grid forming capability
  - Combine energy storage system with renewable energy and evaluate
  - Scale up existing energy storage systems for larger base camps

Thank you!

Questions?

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